INSTRUCTION BOOK
FOR
MODEL 91DA
SENSITIVE RF VOLTMETER

For Serial Number 5752 and above

BOONTON ELECTRONICS CORPORATION

ET- 1489.

SERIAL NO. 7462

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SECTION I

SPECIFICATIONS

Measurement Range:	300 microvolts to 3 volts
Full Scale Ranges:	Full scale readings of 0.001 volts to 3 volts in a 1,3,10 sequence in 8 ranges.
Decibel Range:	80 dB in 8 ranges.
Frequency Range:	20 Kc/s to 1200 Mc/s.
Accuracy:	2% of full scale; 150 Kc/s to 100 Mc/s* 5% of full scale; 50 Mc/s to 400 Mc/s 10% of full scale; 20 Mc/s to 1200 Mc/s. *4% on 0.001V range.
Input Impedance:	See Figure 1.
DC Output:	Linear. At least 1.0 volt across 1,000 ohms.
Meter Calibration:	Linear distribution: 0.9 to 3.2 and 2.8 to 10. Decibels: 0 to -11.
Tube Complement:	2 - BEC 525,001 (12AX7 special) 1 - 7199 1 - 6X4 1 - OA2 1 - 12AT7
Power Requirements:	105 to 125 volts, 58 to 62 cps, 45 watts.
Supplied Accessories:	91-12D RF Probe, 20 Kc/s to 1200 Mc/s 91-13B Probe Tip, 20 Kc/s to 250 Mc/s.
Available Accessories**	91-6C Unterminated BNC Adapter 91-7C 100:1 Voltage Divider, 50 Kc/s to 700 Mc/s. 91-8B 50Ω BNC Adapter 91-14A Type N Tee Adapter++ 91-15A Type N 50Ω Termination++ 91-17D RF Probe, 1 Kc/s to 250 Mc/s

**These accessories are not supplied with the Model 91DA and should be ordered separately. See data sheet following this page for additional details.

++Required for measurements within specified accuracy beyond approximately 250 Mc/s. See page 2.

SECTION II

GENERAL DESCRIPTION

The 91DA RF Voltmeter is a sensitive instrument for the measurement of voltages of 300 microvolts to 3 volts spanning a wide frequency range of 20 kilocycles to 1200 megacycles. In addition to measuring voltage levels in a diversity of rf circuits, the instrument has application for many associated tests. Such measurements include: the frequency response of both active and passive networks, i.e., amplifiers and filters; VSWR and return loss on transmission lines and attendant systems; attenuation and insertion loss of rf attenuators; and high frequency parameters of transistors. With true rms response below 0.03 volt (up to 3 volts with the 91-7C, 100:1 Divider), harmonic distortion of rf waveforms and wide band noise can also be measured.

The instrument is also useful as an rf null detector for bridge measurements and analogous techniques.

The Model 91DA is supplied with RF Probe and removable Probe Tip with grounding clip lead.

The probe tip and companion ground clip are useful for direct measurements to approximately 100 megacycles. Above 100 megacycles the probe may be used directly without the tip but connecting leads must be extremely short to avoid resonant effects. In the special case where it is possible to connect the probe directly to the voltage source, the specified tolerance is maintained to at least 1200 megacycles. The impracticability of such a connection, however, precludes our assuring the accuracy of the 91DA RF Voltmeter above 250 megacycles without the use of the 91-14A Type N Tee Adapter and the 91-15A 50 ohm Termination.

The 91-12D probe with its full-wave crystal detecting circuit produces a true rms response without turnover or harmonic errors for all voltage levels below 0.03 volt, gradually changing to peak-to-peak reading (calibrated in rms) at the higher levels. The probe with the probe tip has a shunt capacitance of approximately 2.5 pF at levels of 0.5 volt or higher, increasing slightly at levels of 0.1 volt or less. The shunt resistance component is also a variable factor, depending on the voltage and frequency. (See Figure 1.)

The use of the 91-7C 100:1 Voltage Divider extends the voltage range to 300 volts (from 50 Kc/s to 700 Mc/s) and provides a true rms response up to 3.0 volts.

SECTION III

OPERATION

3.1 General

This section should be read before using the instrument. It contains information necessary for proper operation of the 91DA RF Voltmeter.

3.2 Controls and Connectors

a. ON - This switch energizes the power transformer when the a-c cord and plug are connected to the proper power source as indicated on the Serial Number nameplate.

b. RANGE - FULL SCALE - VOLTS/DB - This range switch adjusts the amplifier gain, and/or the input attenuator, as well as the proper linearizing network for the selected voltage range.

c. PRESS TO BALANCE - This control introduces a small d-c voltage into the probe circuit to balance out minute thermal voltages that develop in low level d-c circuits. When the control is pushed toward the instrument panel, the meter circuit is altered to permit an upscale reading of the residual noise. The control should then be adjusted for minimum meter reading. The control knob must be released without turning.

d. OUTPUT TERMINALS - Two posts marked (+) and (-) are provided for external instrumentation. The voltage available from these terminals is a linear function of the input voltage and should be approximately 1.0 volt for a full scale meter reading. The output impedance is low and nominally less than 600 ohms.

e. OUTPUT ZERO - This control provides a zero adjustment for the d-c voltage at the output terminals prior to applying r-f voltage to the probe.

f. PROBE - The probe cable connects to the instrument through this jack. It is imperative that the knurled ferrule nut of the probe cable connector be tightened.

3.3 Initial Procedure

a. Before the 91DA is turned on, the meter pointer should be examined to see that it rests on the zero reference line. If necessary, an adjustment may be made with the mechanical zero set on the meter.

b. Turn the instrument on and allow a warm-up period of 15 minutes. To assure maximum accuracy, a warm-up of 1 hour is recommended.

c. Connect the probe to the jack marked PROBE. Connect any of the coaxial adapters to the probe. Do not use the probe tip for this particular test.

d. Turn the RANGE-FULL SCALE switch to the 0.001 volt position and adjust the PRESS TO BALANCE control for a minimum reading. The knob for this control should be pushed toward the panel before an adjustment is made. See Section 3.2c.

3.4 Low Frequency Measurements

Frequencies within the range of 20 kilocycles to about 10 megacycles may be considered low frequencies for 91DA RF Voltmeter applications. Any of the adapters supplied with the instrument may be used in this spectrum. (Exception: the 91-7C 100:1 Voltage Divider has a low frequency limit of 50 kilocycles.)

In general, the high impedance probe may be used with a ground lead of 3 to 6 inches without introducing measuring errors. In the presence of strong fields, however, it is recommended that, where possible, the 91-6C Unterminated BNC Adapter be used.

3.5 High Frequency Measurements

In the frequency domain of 10 megacycles to 250 megacycles, it is permissible to use the probe tip and a conventional ground clip at the lower frequencies whereas measurements at the upper frequencies of this band require special techniques.

Above approximately 100 megacycles, the inductance of any conductor at the input of the probe (either the ground lead or center conductor) may cause an appreciable error in the indicated voltage owing to partial resonance of the lead inductance and input capacitance of the probe. Moreover, any impedance in the ground lead may develop an error voltage owing to circulating currents between instruments. The importance of low impedance connections at high frequencies cannot be overemphasized.

For high impedance measurements at frequencies above 100 megacycles the probe should be connected without leads directly to the voltage source. The input impedance of the probe will have negligible effect upon low impedance circuits, i.e., less than 200 to 300 ohms. An example of such a connection is shown in Figure 2.

High impedance circuits in the range of 50 to 200 megacycles usually take the form of a parallel resonant circuit. Connecting

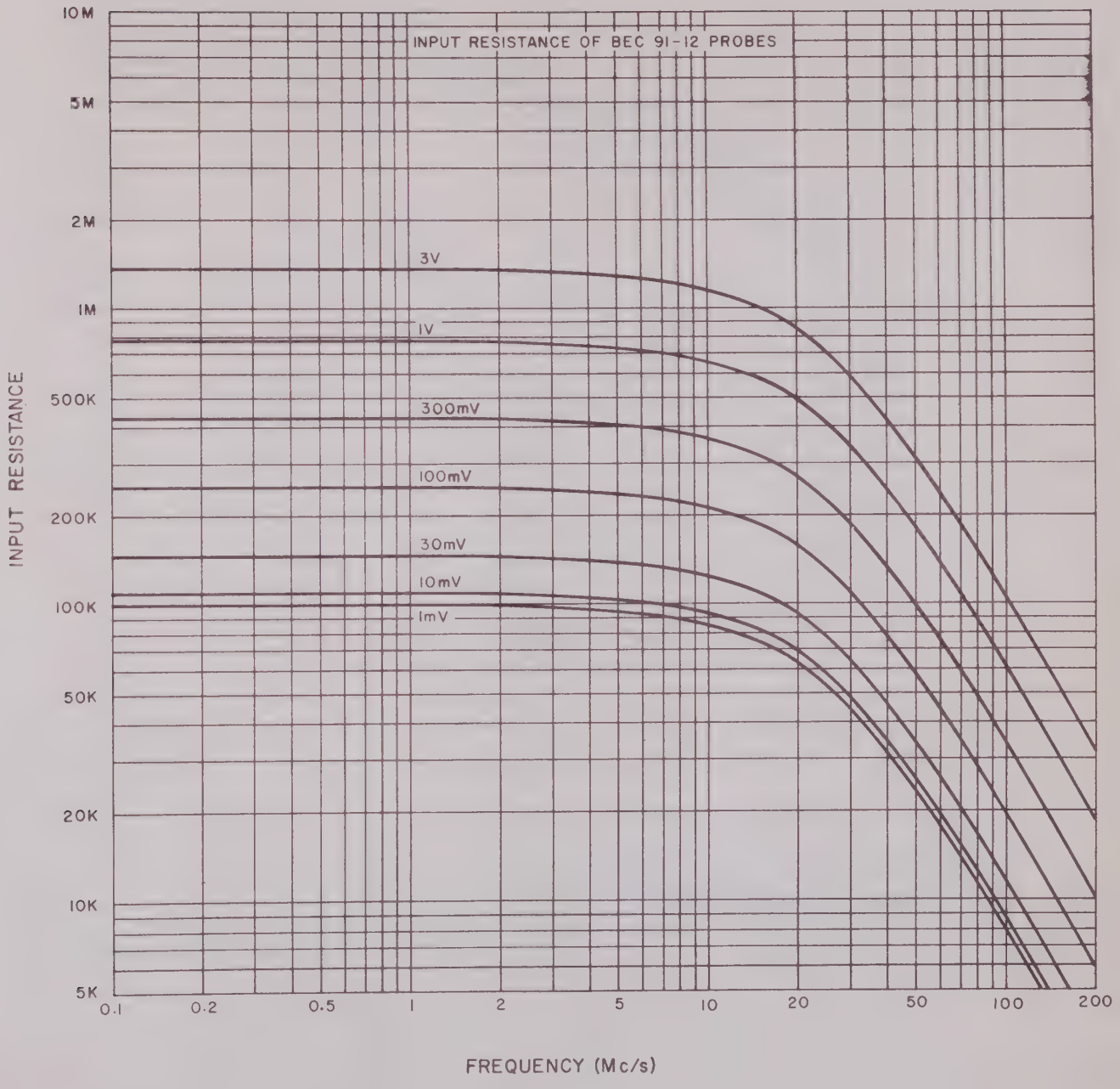
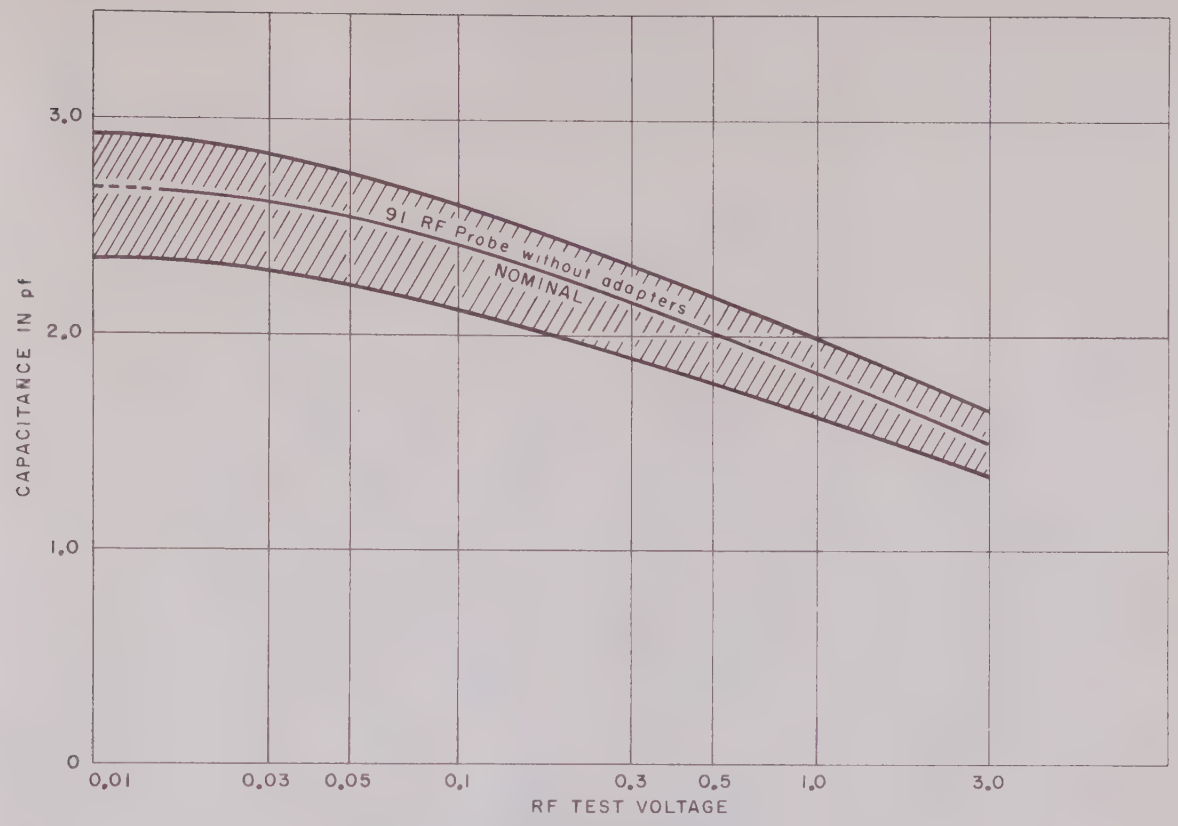
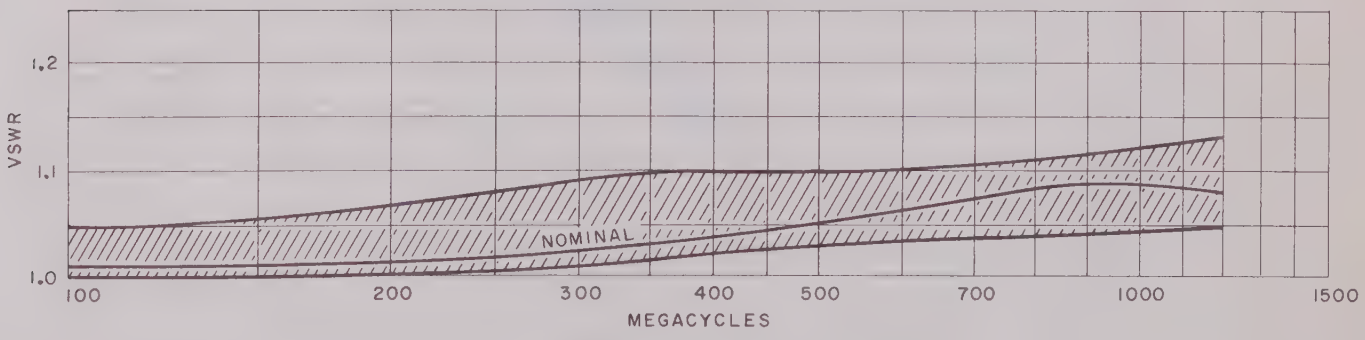

INPUT RESISTANCE OF BEC 91-12 PROBES
10M
5M
2M
1M
500K
200K
100K
50K
20K
10K
5K
INPUT RESISTANCE
3V
1V
300mV
100mV
30mV
10mV
1mV
0.1
0.2
0.5
1
2
5
10
20
50
100
200
FREQUENCY (Mc/s)

Figure 1 a



INPUT CAPACITANCE vs TEST LEVEL
(measured at 10 Mc)

Fig 1b



TYPICAL VSWR OF 91-12 RF PROBE
with 91-14 Type "N" Tee Adapter
terminated in a 91-15 50 Ohm Termination

Fig 1c

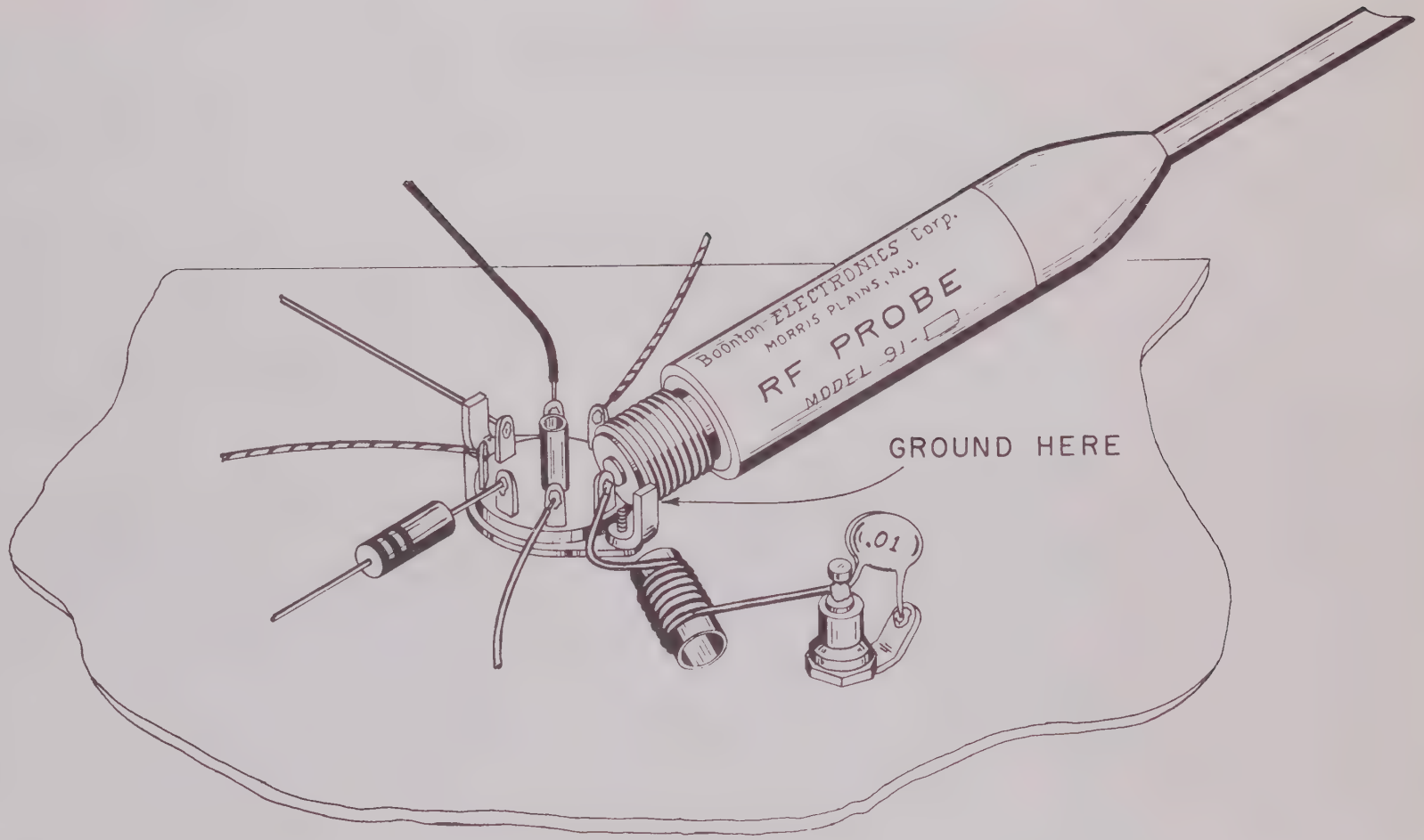

Boonton ELECTRONICS Corp.
MORRIS PLAINS, N.J.
RF PROBE
MODEL 91-
GROUND HERE
.01

Fig. 2

the 91-12D probe to this type of circuit may have a twofold effect: (1) the input capacitance of the probe will detune the circuit, and (2) the resistive component of the input impedance will produce some loading across the circuit.

If the circuit to which the probe is connected is tuned by a variable capacitor, the correction for the first effect is to reduce the capacitance of the circuit by an amount equal to that added by the probe (2 to 3 pF). Correction for the loading effect is not as simple. The input resistance of the probe is to some extent a function of the voltage level applied to the probe. Figure 1 gives nominal values of input resistance vs. frequency for three voltage domains.

If the voltage to be measured exceeds 30 millivolts, the 91-7C 100:1 Voltage Divider is recommended for high impedance measurements at frequencies up to 700 megacycles. This adapter connects directly to the probe and may be introduced into the circuit in the same manner as suggested for the probe in Figure 2. The resistive loading presented by the 91-7B adapter is in the order of 100 megohms at 0.1 megacycles, decreasing to 0.1 megohm at 200 megacycles. Provided the input capacitance of about 2.5 pF exhibited by this adapter can be negated by retuning the circuit, the loading in most r-f circuits will be negligible.

An additional benefit which obtains with the use of the 100:1 Voltage Divider is an extension of the true rms operating region to 3.0 volts.

3.6 UHF Measurements

Voltage measurements are not recommended above 250 megacycles without the use of the 91-14A type N "Tee" Adapter and companion 91-15A 50 ohm Termination. Measurements should preferably be made in electrically short 50 ohm systems ($\ell < 0.1\lambda$). If an electrically long transmission line ($>0.25\lambda$) is interposed between the source and the 91-14A Tee Adapter, the return-loss of the source impedance should be moderately high (say, 20 dB, or more) to reduce the standing waves and attendant errors. The worst condition will exist with a poorly matched source impedance. Under this condition, the measured voltage at the terminus of a long line will be a function of the reflection coefficient, hence the VSWR, of the terminating resistor. In the case of the 91-14A and 91-15A, the maximum VSWR is 1.15 up to 1000 megacycles and less than 1.2 to 1200 megacycles.

It is important that the 91-14A Type N "Tee" Adapter be used in the direction shown in Figure 3. For certain measurements it may be necessary to interpose a length of cable between the "Tee" Adapter and the Termination. If such a connection is made,

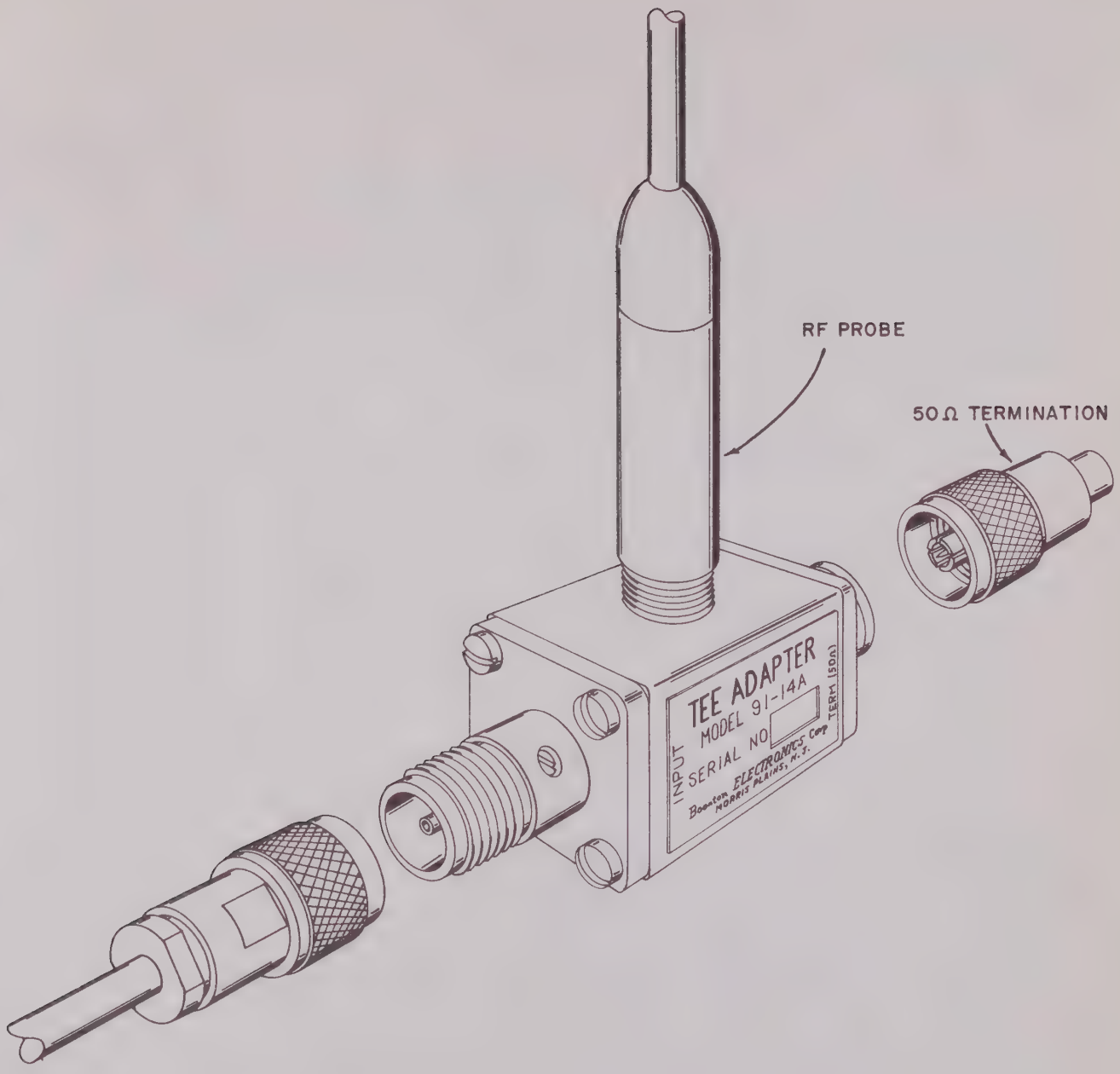

RF PROBE
50Ω TERMINATION
TEE ADAPTER
MODEL 91-14A
SERIAL NO.
Boonton ELECTRONICS Corp
MORRIS PLAINS, N.J.
INPUT
TERM (50Ω)

Fig. 3

the cable selected should be of good quality with a characteristic impedance of 50 ohms.

Provision for disconnecting the 50 ohm termination permits the substitution of a test termination, or the interposition of the tee and probe at any convenient place in a transmission line system.

3.7 High Voltage Measurements

The 91-7C 100:1 Voltage Divider permits the measurement of voltage above 3 volts in the frequency range of 50 Kc/s to 700 Mc/s. At these frequencies, a maximum voltage of 300 volts may be measured with the divider. The d-c voltage rating of the input capacitor, however, is 1000 volts, and the crest voltage of combined d-c and r-f should, therefore, be kept below this value.

As previously mentioned, the 91-7C Adapter extends the true rms range of the RF Voltmeter from 30 millivolts (without the adapter) to 3.0 volts.

High voltage measurements up to 700 Mc/s can be made using the 100:1 Voltage Divider with either the high impedance probe tip, or by connecting the divider to the 91-14A Type Tee Adapter. The VSWR of the terminated tee adapter under this condition will not exceed 1.15 at frequencies up to 700 Mc/s.

3.8 Precautions

For long instrument life and optimum performance, a few precautions should be observed when using the 91DA RF Voltmeter.

3.8.1 Maximum Input Voltage-RF - To secure the many desirable properties of the special diodes used in the voltmeter probe, the peak reverse voltage rating cannot be made greater than about 30 volts with the present state of the art. This limits the maximum rms input level to approximately 9 volts; a margin of 3 to 1 above the maximum range of the instrument.

A simple precaution which will reduce the chance of diode burn-out is to use the 91-7C 100:1 Voltage Divider when working with r-f voltages above, say 100 millivolts, at frequencies from 50 Kc/s to 700 Mc/s. In addition, the advantages outlined in Section 3.7 also obtain.

3.8.2 Maximum Input Voltage - DC - RF Voltages, superimposed on d-c potentials of up to 400 volts, may be measured without damaging the probe diodes. Higher d-c protection (to 1000V) may be obtained with the use of the 91-7C 100:1 Voltage Divider with an attendant reduction in sensitivity. Although protection of the probe for d-c voltages up to 400

volts is provided in the design, pulsing of the probe with higher d-c voltage may damage the diodes. Wherever possible, the circuit of Figure 4 should be used to remove the d-c component prior to measuring the r-f voltage.

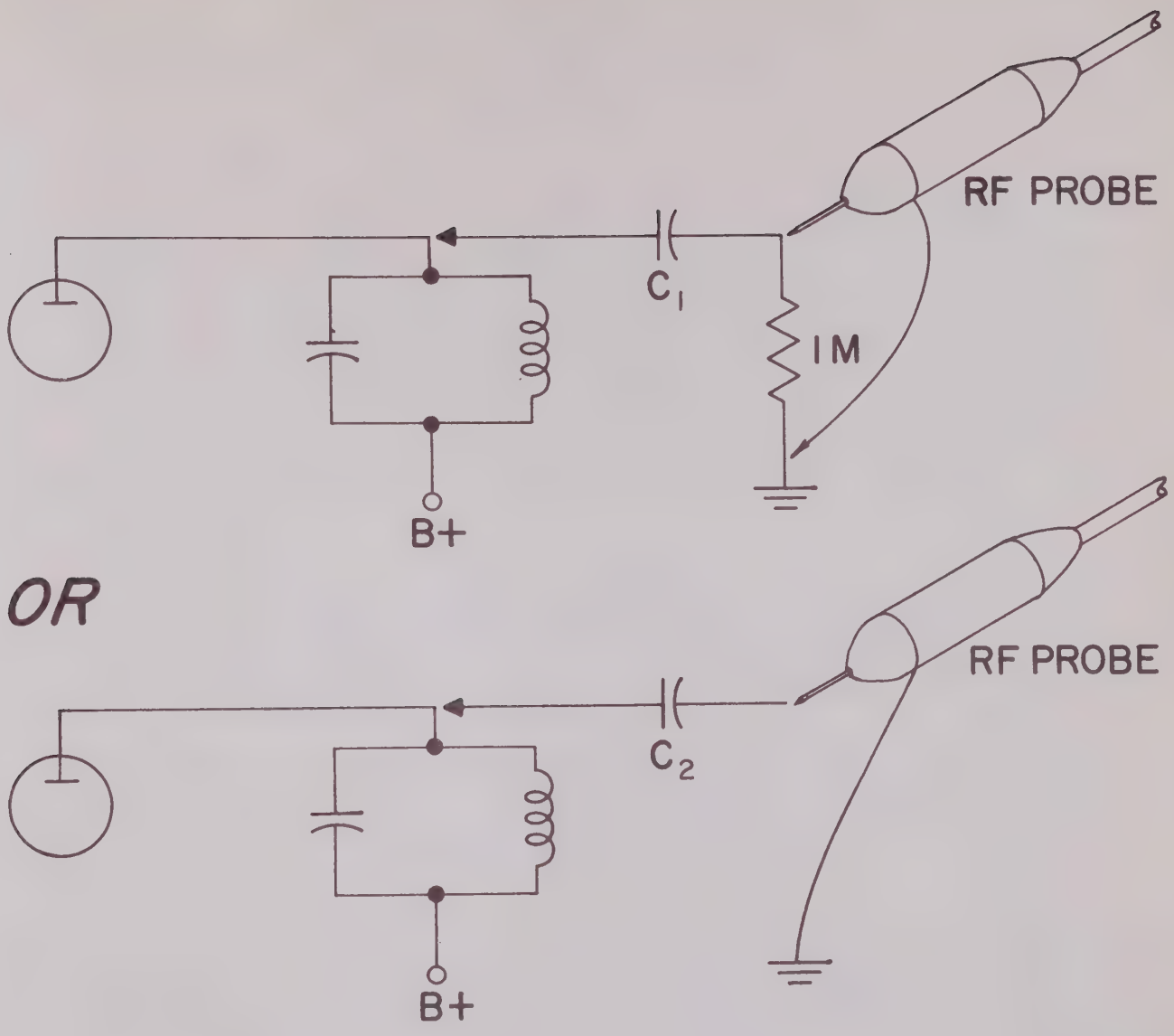
3.8.3 High Intensity, Low Frequency Fields - The amplifier section of the 91DA RF Voltmeter has a maximum gain at 60 cps of approximately 120 dB. Although the instrument incorporates both magnetic and electrostatic shielding, the voltmeter cannot be expected to function properly on its more sensitive ranges in the proximity of strong 60 cycle fields.

One source of considerable interference, common in many laboratories, is the magnetic type of 60 cycle line voltage stabilizer. The 91DA RF Voltmeter should be operated at a suitable distance from such devices as well as other devices which generate high intensity fields.

It is suggested when using the RF Voltmeter on its most sensitive range in the proximity of any a-c line operated equipment, that the adjacent equipment be momentarily de-energized to note its effect upon the indication of the voltmeter.

3.8.4 High Intensity, High Frequency Fields - The measurement of low level r-f voltages in the presence of high level, high frequency fields requires excellent shielding if gross errors are to be avoided. In particular, the use of the probe tip and companion ground clip is precluded. Moreover, the balancing operation required for the most sensitive range (1 millivolt) should be performed with the probe connected to the circuit which should be temporarily disabled.

It is likely that such measurements will require special fixtures and jigs to ensure accurate measurements.



C_1 should be a sensible short circuit at the measuring frequency.

C_2 should be 100 pf or less.

METHODS FOR PROBE ISOLATION FOR HIGH DC VOLTAGES

Fig 4

SECTION IV

TECHNICAL DESCRIPTION

4.1 General

The 91DA RF Voltmeter employs a miniature, low capacitance probe which converts the r-f voltage to a proportional d-c potential. This d-c voltage is in turn converted to a 60 cycle a-c signal by a special low noise mechanical chopper. A selective amplifier follows the chopper and raises the 60 cycle level to a value sufficient for rectification, linearization, and metering. The DC Output Cathode Follower is also fed from this point. Additional circuitry is provided to spread the useful portion of the meter scale over a larger-than-normal percentage of the pointer range for greater readability.

4.2 Probe

The RF Probe contains a blocking capacitor and two high frequency diodes connected for full-wave rectification. Adequate by-passing and resistive isolation is included. The probe is connected to the voltmeter cabinet by means of a flexible low noise cable and connector.

Owing to the possibility of degradation of performance by replacing diodes in the probe without complete facilities for calibrating the instrument, components in the probe have not been shown on the schematic.

4.3 Chopper Modulator

The SPDT mechanical chopper has break-before-make contacts and operates from the 6.3 volt, 60 cycle winding of the power transformer. A low pass RC filter ahead of the chopper suppresses any 60 cycle voltage which may be introduced through the probe. After using the voltmeter on the 1 or 3 volt range, the capacitors in this filter will require 40 to 60 seconds to discharge sufficiently to permit operation on the 1 millivolt range.

A resistive attenuator appears between the output of the chopper and the input of the amplifier. The attenuator has five adjustments which are described in Section 5.

4.4 Amplifier

The amplifier in the 91DA raises the signal level from the chopper to a level adequate for converting the square-law response from the probe (for measured voltages of less than 30 millivolts) to a linear direct current for the meter. As the measured voltage increases, the extent of the conversion is reduced.

The BEC 525,001 (12AX7) Preamplifier is contained within the shielded box attached to the front subpanel. The box also houses the input attenuator and switching for feedback control in the preamplifier, as well as the chopper and its circuitry.

The preamplifier is followed by a second 12AX7 which drives the selective output amplifier.

The output stages consist of a combination pentode-triode tube (type 7199). The pentode operates as a normal amplifier and is coupled to the triode which functions principally as a cathode follower. Negative feedback is taken from the triode cathode in a conventional manner to the second cathode of V2. It is also applied through a frequency selective twin-tee network to the grid of the pentode section.

These circuits produce an output amplifier which is broadly tuned to 60∿ having approximately 18 dB of attenuation at 120∿. The output impedance of the cathode follower is sufficiently low to drive the rectifier circuit without appreciable distortion.

The combination of regulated d-c heater and plate voltage for the two 12AX7's, as well as negative feedback around all stages, makes the instrument calibration sensibly independent of line voltage changes from 105 to 125 volts.

4.5 Rectifier and Meter Circuit

The meter rectifier is a half-wave voltage doubler. The d-c voltage derived from this circuit is applied to a network of stabistors (voltage sensitive resistors) and adjustable resistors which are employed to convert the amplified non-linear response of the r-f probe to a linear current for the indicating meter.

4.6 DC Output Cathode Follower

This stage is provided to drive external recording equipment. The output voltage at the front panel terminals should be approximately 1.0 volt (relative to full scale) when connected to a 1000 ohm load.

Although the d-c output voltage is a direct linear function of the r-f input voltage (as opposed to the expanded, but equally divided meter divisions), the d-c output is usable only when the meter is on some portion of its calibrated range.

4.7 Power Supply

A conventional full-wave rectifier, using a 6X4 vacuum tube, furnishes the necessary high voltage d-c potentials for the instrument. A portion of this voltage is regulated with an OA2 gas discharge tube for the plate voltage of the first and second amplifier tubes.

The heater voltage of these same stages is rectified and regulated using a silicon rectifier (full-wave bridge) and two germanium pnp power transistors.

Heater voltage for the output stage and the DC Cathode Follower is derived from the 6.3 volt transformer winding.

SECTION V

MAINTENANCE

5.1 Periodic Checking

The Model 91DA Voltmeter is designed to give long periods of service without maintenance when operated in accordance with the instructions in this book. It is recommended, however, that the instrument be checked periodically using reliable standards to ensure against errors resulting from deterioration of either the tubes or the chopper. To make these tests, it is necessary to have a signal source of 200 Kc/s to 500 Kc/s with less than 1% distortion at levels up to 3 volts across 50 ohms, a suitable attenuator to adjust this level between 300 microvolts and 3 volts, and a precision electronic voltmeter, such as the Hewlett Packard Model 400H, to monitor the signal source. The high frequency response of the 91DA may be checked with laboratory a-c to d-c transfer standards. The Ballantine Model 440 Micropotentiometer is recommended for this purpose.

5.2 Calibration Precautions

To check the calibration accuracy on an RF Voltmeter having the sensitivity and bandwidth of the Model 91DA, it is necessary to take precautions to avoid errors resulting from stray pick-up voltages. (See paragraphs 3.8.3. and 3.8.4.) A well shielded signal source must be used in conjunction with coaxial connections to both the Model 91DA and the standard reference meter. Even with such equipment it is sometimes possible for the reference meter to pick up stray RF signals and feed them to the probe. Check for this condition by disconnecting the standard meter and noting a change in level.

5.3 Calibration Check Procedure

Each range of the 91DA should be checked at a voltage representing 90% of full scale value. If these check points agree within ±1.5% of the standard, it is recommended that no adjustment be made. If the check points deviate by more than ±1.5% from the standard, the calibration adjustment procedure as outlined in paragraph 5.5 should be followed. If it is impossible to adjust the instrument to within 1% of the standard meter, it is recommended that a trouble shooting procedure be followed as outlined in paragraph 5.4.

5.4 Trouble Shooting Procedure

5.4.1 Case Removal - The instrument may be removed from its case after first removing the four screws located on each side of the case.

5.4.2 Tube Replacement - If the tube V101 should become weak or noisy, it should be replaced with BEC 525,001 or a commercial low noise 12AX7 which has low microphonism as well as low flicker noise. The Telefunken ECC83/12AX7 has consistently met these requirements. After replacing defective tubes, recheck the calibration as outlined in paragraph 5.3 and, if necessary, adjust the instrument as described in paragraph 5.5.

5.4.3 Chopper Replacement - Poor chopper performance is usually evidenced by an abnormally high meter indication on the 0.001 volt range for zero input voltage. (See Section 3.8.3 and 3.8.4.) The meter pointer should drop to the zero reference line after proper adjustment of the PRESS TO BALANCE control. If the meter cannot be zeroed, a replacement chopper should be tried. If the new chopper does not correct the difficulty, replace the original chopper. If a new chopper does correct the difficulty, the calibration should be rechecked and adjusted, if necessary, after a run-in period of an hour or two.

5.4.4 Voltage and Resistance Tests - After determining that the trouble cannot be cured by replacement of tubes or chopper, as described previously, it is advisable to make a systematic check of AC voltage, DC voltage and resistance at each socket pin. Table 2 shows the nominal AC and DC voltages to ground from each socket pin number. Table 3 shows the nominal resistance values expected for each point. Large or erratic deviations from the listed values of voltage or resistance will serve as a clue in tracking down a faulty component. Once the trouble has been found and corrected, the calibration must be rechecked and readjusted as outlined in paragraph 5.3 and paragraph 5.5.

5.5 Calibration Adjustment Procedure

Before making any calibration adjustment, it is essential to provide the necessary reference standards as described in paragraph 5.1 and take all precautions as outlined in paragraph 5.2. The calibration adjustment shall then be made as outlined in the following procedure.

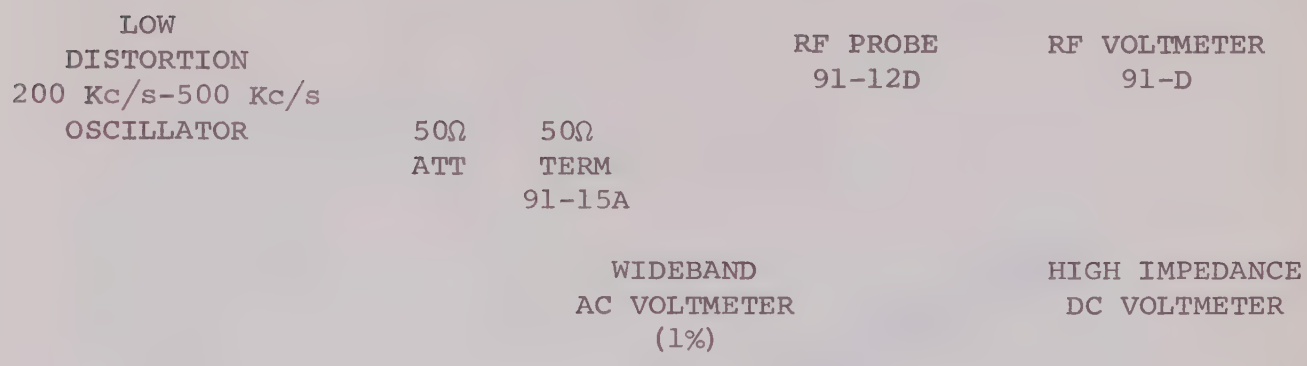
5.5.1 Equipment Required

a. A low distortion (< 1%) oscillator (200 Kc/s to 500 Kc/s) capable of generating 3 volts across 50 Ω.

b. A wideband a-c voltmeter with an accuracy of 1% or better, with a range of 300 microvolts to 3 volts.

c. A 50 Ω r-f attenuator with sufficient adjustment in conjunction with the oscillator level control to permit reduction of the level to 30[illegible] icrovolts.

5.5.2 Calibration Set-Up - All connections on the following block diagram should be made with coaxial cable and connectors.



5.5.3 Preliminary Adjustment

a. Connect a high impedance dc voltmeter to the output of the meter rectifier circuit (junction of green lead and 120K resistor on top terminal board - see Figure 5). This point will be referred to as the dc test point.

b. With zero input to the 91DA, set the RANGE switch to 0.001 volt and adjust the PRESS TO BALANCE control for minimum indication on the meter.

c. Turn the RANGE switch to the 0.01 volt position and increase the input level to 0.01 volt.

d. Adjust 0.01 control (R143) at the top of preamp housing for a reading of -16 volts at the dc test point.

5.5.4 Calibration - Table I describes the procedure for calibrating each range of the 91DA, provided the steps of paragraph 5.5.3 have been followed. (Note: Access to linearity adjustments, i.e., controls 2 through 12, is possible by removing the Access Plate on the left side of the cabinet.)

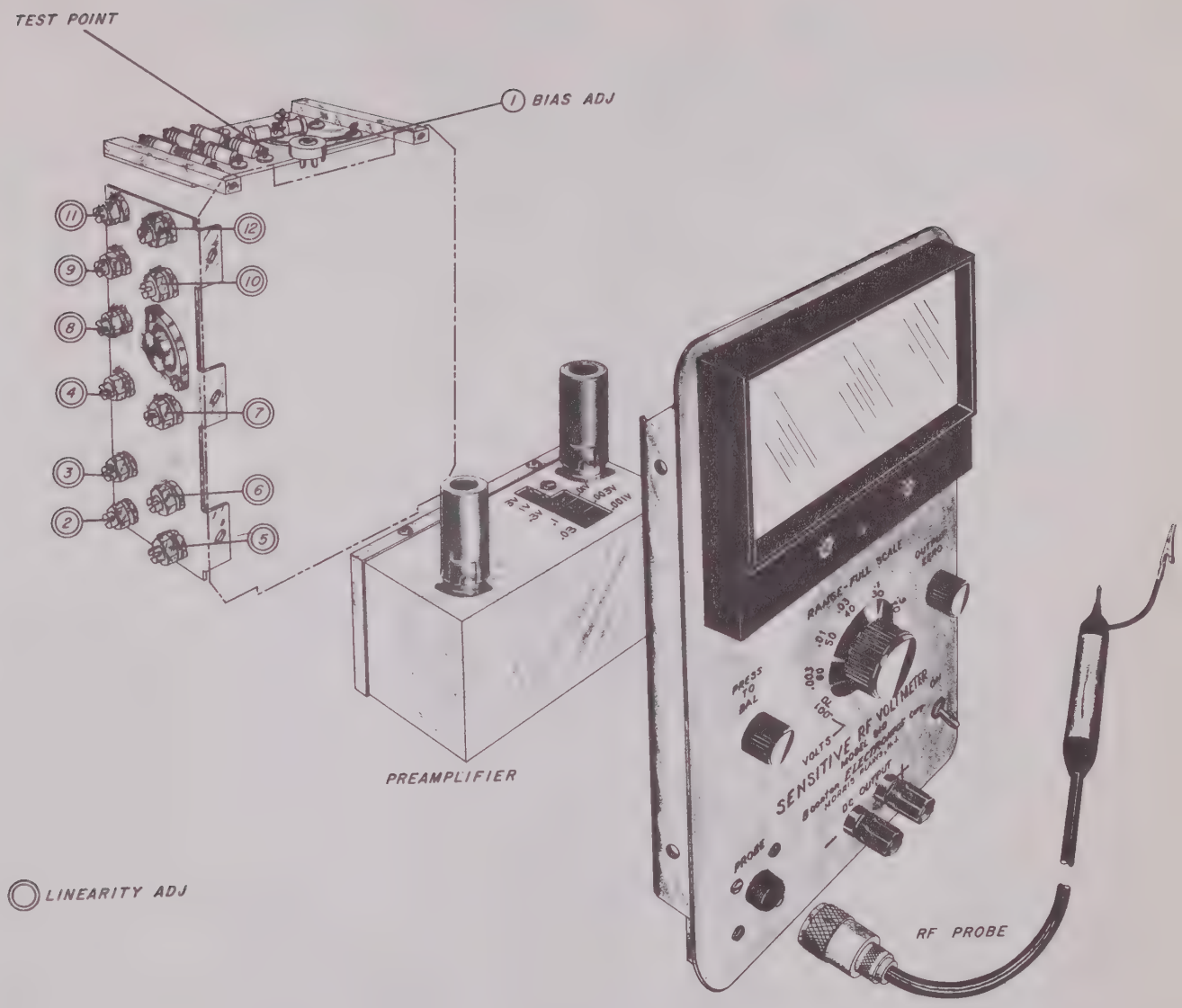


Fig. 5

91DA
9-64

TABLE 1

CALIBRATION TABLE

STEP	RANGE SETTING	APPLIED VOLTAGE	ADJUST CONTROL NO.	COMMENTS
1	0.01	0.003	1(R341)	This control is located on top terminal board.
2	0.01	0.005	2	Recheck step 1 until both points are calibrated.
3	0.01	0.008	3	
4	0.01	0.01	4	Repeat steps 1, 2, 3, & 4.
5	0.001	0.001	0.001 (R138)	Caution: Check PRESS TO BALANCE for minimum meter reading.
6	0.003	0.003	0.003 (R142)	0.001, 0.003, and 0.01 volt ranges should now be calibrated.
7	0.03	0.01	0.03 (R144)	
8	0.03	0.015	5	Recheck step 7 until steps 7 and 8 are correct.
9	0.03	0.025	6	
10	0.03	0.03	7	Repeat steps 7 through 10.
11	0.1	0.03	0.1 (R145)	
12	0.1	0.05	8	
13	0.1	0.1	9	Recheck steps 11 and 12 until steps 11, 12 and 13 are correct.
14	0.3	0.1	0.3 (R146)	
15	0.3	0.3	10	Recheck step 14 until steps 14 and 15 are correct.
16	1.0	0.3	1.0 (R147)	
17	1.0	1.0	11	Recheck step 16 until steps 16 and 17 are correct.
18	3.0	1.0	3.0 (R148)	
19	3.0	3.0	12	Recheck step 18 until steps 18 and 19 are correct.

TABLE 2

VOLTAGE MEASUREMENTS

PIN	1	2	3	4	5	6	7	8	9	
V101 BEC 525001	72V	0V	0.4V	-4.0V	-4.0V	88V	0V	0.6V	0V	DC
V301 12AX7	86V	0V	0.37V	-9.0V	-9.0V	70V	0V	0.37V	-4.0V	DC
	0.1V	0.075V	-	-	-	0.075V	0.0015V	-	-	AC
V302 7199	360V	32V	63V	-	0V	1.5V	0V			DC
	-	16.5V	-	5.7V	0V	-	0.1V	15V		AC
V303 12AT7	340V		2.9V			340V		4.9V	0V	DC
	-	-	-	6.3V	6.3V	-	-	-	0V	AC
V201 6X4							360V			DC
	325V		0V	6.3V		325V				AC
V202 OA2	150V	0V		0V	150V		0V			DC

CONDITIONS:

(1) DC Voltage Measurements with vacuum tube voltmeter (BEC 95A).

(2) AC Voltage Measurements with F.W. average responding vacuum tube voltmeter (Ballantine 314).

(3) 117V 60 cycles line input.

(4) All measurements to chassis.

(5) Input 10 mV at (300 Kc/s).

TABLE 3

D.C. RESISTANCE TO GROUND

PIN #	1	2	3	4	5	6	7	8	9
V101 BEC 525,001		22M	6.8K				2.2M	6.8K	
V301 12AX7		1M	1.2K				1M	2.2K	
V302 7199						1.2K	1M	20K	1M
V303 12AT7			3K-5K				50K-75K	4K-6K	
V201 6X4	1K					1K			
V202 0A2		0		0			0		

D.C. Resistance Measurements with Simpson 260 (polarity +, negative (blk) lead to ground).

TABLE 4

D.C. RESISTANCE TO CATHODE OF 6X4 RECTIFIER (PIN 7)

PIN #	1	2	3	4	5	6	7	8	9
V101 BEC 525,001	1M					500K			
V301 12AX7	200K					470K			
V302 7199		360K	820K						
V201 12AT7	550Ω					550Ω			
V202 0A2	8.0K				8.0K				

D.C. Resistance Measurements with Simpson 260 (polarity +, negative (blk) lead to 6X4 cathode).

TABLE OF REPLACEABLE PARTS

Reference	Description	BEC Part No.
C101	Capacitor, Mylar 0.1 µF 200 V	230,116
C102	" Mylar 0.1 µF 200 V	230,116
C103	" Mylar 0.1 µF 200 V	230,116
C104	" Mylar 0.1 µF 200 V	230,116
C105	" Mylar 0.0033 µF 200 V	230,119
C106	" Mylar 0.022 µF 200 V	230,101
C107	" Mylar 0.0033 µF 200 V	230,119
C108	" Met.Paper 1.0 µF 200 V	235,104
C109	" Mylar 0.01 µF 200 V	234,027
C201 A & B	" Elect. 2X500 µF 16 V	283,142
C202 A,B, & C	" Elect. 3X20 µF 450 V	283,113
C301	" Mylar 0.01 µF 200 V	234,027
C302	" Mylar 0.022 µF 200 V	230,101
C303	" Mylar 0.068 µF 200 V	234,029
C304	" Mylar 0.068 µF 200 V	234,029
C305	" Mylar 0.068 µF 200 V	234,029
C306	" Mylar 0.022 µF 200 V	230,101
C307	" Mylar 0.47 µF 400 V	234,047
C308	" Elect. 20 µF 6 V	283,153
C309	" Mylar 0.01 µF 200 V	234,027
C310	" Mylar 0.22 µF 200 V	234,015
C311	" Elect. 4 µF 450 V	283,135
C312	" Elect. 200 µF 6 V	283,147
C313	" Met.Paper 1 µF 400 V	234,031
C314	" Elect. 4 µF 250 V	283,136
C315	" Mylar 0.022 µF 200 V	230,101
C316	" Elect. 10 µF 150 V	283,152
C317	" Mylar 0.022 µF 200 V	230,101
CR201	Rectifier, Silicon Sarkes Tarzian	532,009
CR301	Diode SG3113	530,040
CR302	" SG3113	530,040
CR303	" 1N600	530,008
CR304	" 1N600	530,008
CR305	" SG3113	530,040
CR306	" SG3113	530,040
CR307	" 1N600	530,008
CR308	" 1N600	530,008
CR309	" Special	530,025

Reference		Description	BEC Part No.
DS201	Lamp	GE #323 3 V	545,106
DS201	Lamp	GE #323 3 V	545,106
F201	Fuse	MDL-1.0 Amp.	545,510
G101	Chopper	Special	540,113
L101	R.F. Choke	4.7 µH Nytronics WEE 4.7	400,113
L201	Choke	Stancor # C 1707	440,001
M101	Meter	Special 0-200 µA	554,136
R101	Resistor, Comp.	22 M 1/2 W 5%	301,191
R102	" Comp.	4.7 K 1/2 W 5%	301,103
R103	" Var.(Spec)	50 K 2 W 20%	311,168
R104	" Comp.	22 M 1/2 W 5%	301,191
R105	" Comp.	8.2 K 1/2 W 5%	301,109
R106	" Dep. Car.	332 K 1/2 W 1%	306,541
R107	" Dep. Car.	332 K 1/2 W 1%	306,541
R108	" Dep. Car.	5.36 M 1/2 W 1%	306,790
R109	" Dep. Car.	5.36 M 1/2 W 1%	306,790
R110	" Dep. Car.	619 K 1/2 W 1%	306,573
R111	" Dep. Car.	619 K 1/2 W 1%	306,573
R112	" Dep. Car.	47.5 K 1/2 W 1%	306,440
R113	" Dep. Car.	47.5 K 1/2 W 1%	306,440
R114	" Dep. Car.	12.4 K 1/2 W 1%	306,371
R115	" Dep. Car.	12.4 K 1/2 W 1%	306,371
R116	" Dep. Car.	1.91 K 1/2 W 1%	306,273
R117	" Dep. Car.	1.91 K 1/2 W 1%	306,273
R118	" Dep. Car.	1.15 K 1/4 W 1%	305,247
R119	" Dep. Car.	1.15 K 1/4 W 1%	305,247
R120	" Comp.	100 K 1/2 W 5%	301,135
R121	" Comp.	100 K 1/2 W 5%	301,135
R122	" Comp.	15 K 1/2 W 5%	301,115
R123	" Comp.	390 K 1/2 W 5%	301,149
R124	" Comp.	100 Ω 1/2 W 5%	301,063
R125	" Comp.	2.2 K 1/2 W 5%	301,095
R126	" Comp.	6.8 K 1/4 W 10%	300,013
R127	" Comp.	22 M 1/2 W 5%	301,191
R128	" Comp.	120 Ω 1/2 W 5%	301,065
R129	" Comp.	1 M 1/2 W 5%	301,159
R130	" Comp.	6.8 K 1/2 W 5%	315,012
R131	" Comp.	1 K 1/4 W 10%	300,008
R132	" Comp.	6.8 K 1/4 W 10%	300,013
R133	" Comp.	2.2 M 1/2 W 5%	301,167
R134	" Comp.	470 K 1/2 W 5%	301,151
R135	" Comp.	2.2 K 1/2 W 5%	301,095

Reference		Description					BEC Part No.
R136	Resistor,	Comp.	1	K	1/4 W	10%	300,008
R137	"	Met. Film	820	K	1 W	5%	315,022
R138	"	Var.	1	M	1/4 W	20%	311,183
R139	"	Comp.	820	K	1/2 W	5%	301,157
R140	"	Var.	25	K	2 W	10%	311,171
R141	"	Met. Film	82	K	1/2 W	5%	315,007
R142	"	Var.	200	K	1/4 W	20%	311,185
R143	"	Var. W.W.	10	K	1/2 W	10%	311,184
R144	"	Var. W.W.	10	K	1/2 W	10%	311,184
R145	"	Var. W.W.	10	K	1/2 W	10%	311,184
R146	"	Var. W.W.	10	K	1/2 W	10%	311,184
R147	"	Var. W.W.	10	K	1/2 W	10%	311,184
R148	"	Var. W.W.	10	K	1/2 W	10%	311,184
R201	"	Comp.	1	M	1 W	20%	302,128
R202	"	W.W.	2.4	Ω	1 W	5%	310,001
R203	"	W.W.	7.5	K	20 W	5%	312,107
R204	"	Comp.	680	Ω	1/2 W	5%	301,083
R205	"	Comp.*	1.1	K	1/2 W	5%	301,088
R206	"	Comp.	2	K	1/2 W	5%	301,094
R301	"	Comp.	1	M	1/2 W	5%	301,159
R302	"	Comp.	470	K	1/2 W	5%	301,151
R303	"	Comp.	2.2	K	1/2 W	5%	301,095
R304	"	Comp.	1	M	1/2 W	5%	301,159
R305	"	Comp.	200	K	1/2 W	5%	301,142
R306	"	Dep. Car.	1.21	K	1/2 W	1%	306,253
R307	"	Var.	15	K	2 W	20%	311,109
R308	"	Var.	10	K	2 W	20%	311,102
R309	"	Dep.Car.	121	K	1/2 W	1%	306,488
R310	"	Met.Film	200	K	1 W	5%	315,019
R311	"	Met.Film	200	K	1 W	5%	315,019
R312	"	Dep.Car.*	5.9	K	1/2 W	1%	306,332
R313	"	Var.	25	K	2 W	20%	311,115
R314	"	Var.	10	K	2 W	20%	311,102
R315	"	Var.	10	K	2 W	20%	311,102
R316	"	Comp.	1	M	1/2 W	5%	301,159
R317	"	Comp.	1.8	K	1/2 W	5%	301,093
R318	"	Comp.	360	K	1/2 W	5%	301,148
R319	"	Comp.	820	K	1/2 W	5%	301,157
R320	"	Comp.	1	M	1/2 W	5%	301,159
R321	"	Comp.	220	Ω	1/2 W	5%	301,071
R322	"	W.W.	20	K	20 W	5%	312,111
R323	"	Var.	15	K	2 W	20%	311,109
R324	"	Var.	25	K	2 W	20%	311,115
R325	"	Var.	10	K	2 W	20%	311,102
R326	"	Var.	10	K	2 W	20%	311,102
R327	"	Var.	10	K	2 W	20%	311,102
R328	"	Var.	10	K	2 W	20%	311,102

Reference	Description	BEC Part No.
R329	Resistor, Comp. 120 K 1/2 W 5%	301,137
R330	" Comp. 33 K 1/2 W 5%	301,123
R331	" Dep. Car. 4.22 K 1/4 W 1%	305,314
R332	" Dep. Car. 1.78 K 1/4 W 1%	305,269
R333	" Dep. Car. 1.47 K 1/4 W 1%	305,259
R334	" Dep. Car. 1.54 K 1/4 W 1%	305,262
R335	" Dep. Car. 3.48 K 1/4 W 1%	305,304
R336	" Comp. 4.7 M 1/2 W 5%	301,175
R337	" Comp. 100 K 1/2 W 5%	301,135
R338	" Comp. 3.6 K 1/2 W 5%	301,100
R339	" Comp. 33 K 1/2 W 5%	301,123
R340	" Comp. 1 M 1/2 W 5%	301,159
R341	" Var. 2 M 1/10W 10%	311,176
R342	" Comp. 470 K 1/2 W 5%	301,151
R343	" Comp. 470 K 1/2 W 5%	301,151
R344	" Comp. 6.8 K 1/2 W 5%	301,107
R345	" Comp. 68 K 1/2 W 5%	301,131
R346	" Comp. 3.9 K 1/2 W 5%	301,101
R347	" Dep. Car. 2.49 M 1/2 W 1%	306,746
R348	" Comp. 150 K 1/2 W 5%	301,139
S101	Switch 3 Pole, 8 Pos. Spec.	466,151
S201	Switch SPST Carling #110-63	465,105
S301	Switch 5 Pole, 8 Pos. Spec.	466,140
T201	Transformer Power, Special	446,016
V101	Electron Tube 12AX7, Special	525,001
V201	Electron Tube 6X4	526,6X4
V202	Electron Tube OA2	526,OA2
V301	Electron Tube 12AX7, Special	525,001
V302	Electron Tube 7199	526,7199
V303	Electron Tube 12AT7, Special	525,002
VR201	Diode 1N1775	530,046
Q201	Transistor 2N554	528,003
Q202	Transistor 2N404A, or 2N1415	528,002

* May be factory selected

Warranty

Boonton Electronics Corporation warrants its products to the original Purchaser to be free from defects in material and workmanship and to operate within applicable specifications for a period of one year from date of shipment, provided they are used under normal operating conditions. This warranty does not apply to vacuum tubes that have given normal service, to sealed assemblies which have been opened, or to any item which has been repaired or altered without our authorization.

We will repair or, at our option, replace at no charge any of our products which are found to be defective under the terms of this warranty.

SHIPPING INSTRUCTIONS

If it becomes necessary to ship the instrument, the following steps should be followed:

a. Wrap the instrument with heavy wrapping paper and seal the seams with gummed tape. Place in fibreboard carton large enough to permit three inches of soft packing material between instrument and sides of box.

b. Alternatively Boonton Electronics will provide an appropriate shipping container and packing materials at nominal cost. These may be obtained by writing to the Sales Department, Boonton Electronics Corporation, Route 287 at Smith Rd., Parsippany, N. J. 07054.

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